THE PROCESS OF ACHIEVING COLLABORATIVE KNOWLEDGE IN ASYNCHRONOUS COLLABORATION (CASC)

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OUTLINE

- Summary of Overall Objectives and FY03 / FY04 Objectives
- Expected Final Products
- CASC Application and Impact
- Research Questions and Contribution to Collaboration Technology
- Phase I, II and III Experiments and Current Empirical Findings
- Accomplishments
- Transition and Demonstration of Structural Model of Team Collaboration in NAVAIR and Naval Postgraduate School CKM Testbeds via modified Ewall software
- Recent / Planned Publications
- Lessons Learned

PROJECT SUMMARY OVERVIEW

- **Overall Goal:** understand the unique cognitive mechanisms that should be employed to optimize collaborative decision-making activity in a geographically distributed and time-delayed situation

- **Objectives:**
  (1) To understand the cognitive processes of building knowledge in an asynchronous, distributed collaboration environment
  (2) To develop an empirically-based theory of collaboration, including knowledge building components, during asynchronous,distributed collaboration
  (3) To understand how agents can support humans in achieving collaborative knowledge during asynchronous, distributed collaborative problem solving

- **FY03 / 04 Objectives:**
  (1) Conduct experiments in collaborative problem solving in both face-to-face and asynchronous, distributed environments to understand the unique cognitive processes within asynchronous, distributed collaboration
  (2) Update model of collaboration based on experimental results

EXPECTED FINAL PRODUCTS

1. **Empirical Data / Journal Articles**

   - **Describing the cognitive processes of building knowledge with distributed team members engaged in asynchronous, quick response collaboration**

2. **Empirically-based Theory for Asynchronous, Distributed Collaboration including Knowledge Building Components**

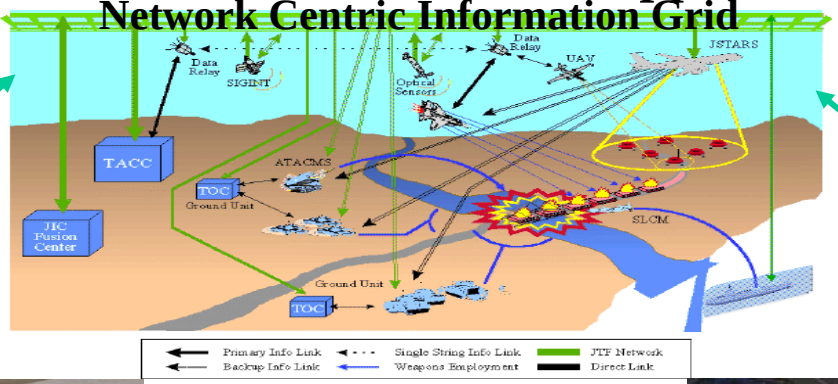
3. **Empirical Data on Agent Support for Achieving Collaborative Knowledge in Asynchronous, Distributed Collaboration**

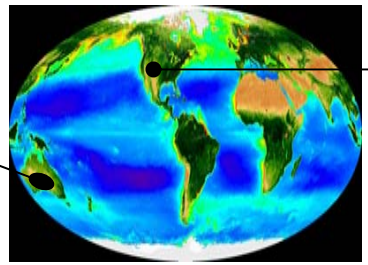
4. **Demonstration of the Knowledge Building Processes during Asynchronous, Distributed Collaborative Problem Solving using an Integrated EWall / NEO Scenario Testbed.**

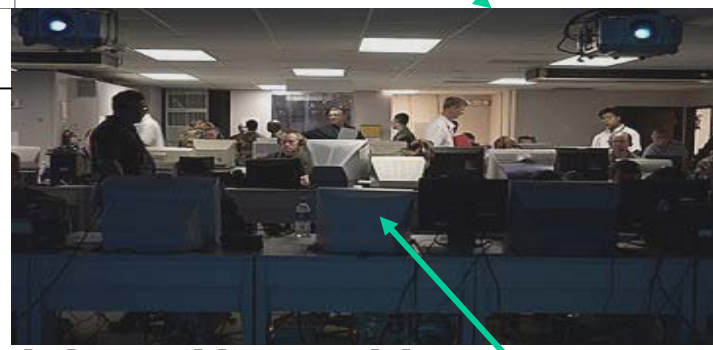
   - **Testbed is laptop based, portable and can be used to demonstrate Ewall collaboration tool and knowledge building processes to other agencies (e.g. NPGS, universities) and Operational communities (e.g. PACOM, JIFCOM, SPAWAR FORCEnet)**

Network Centric Warfare Application

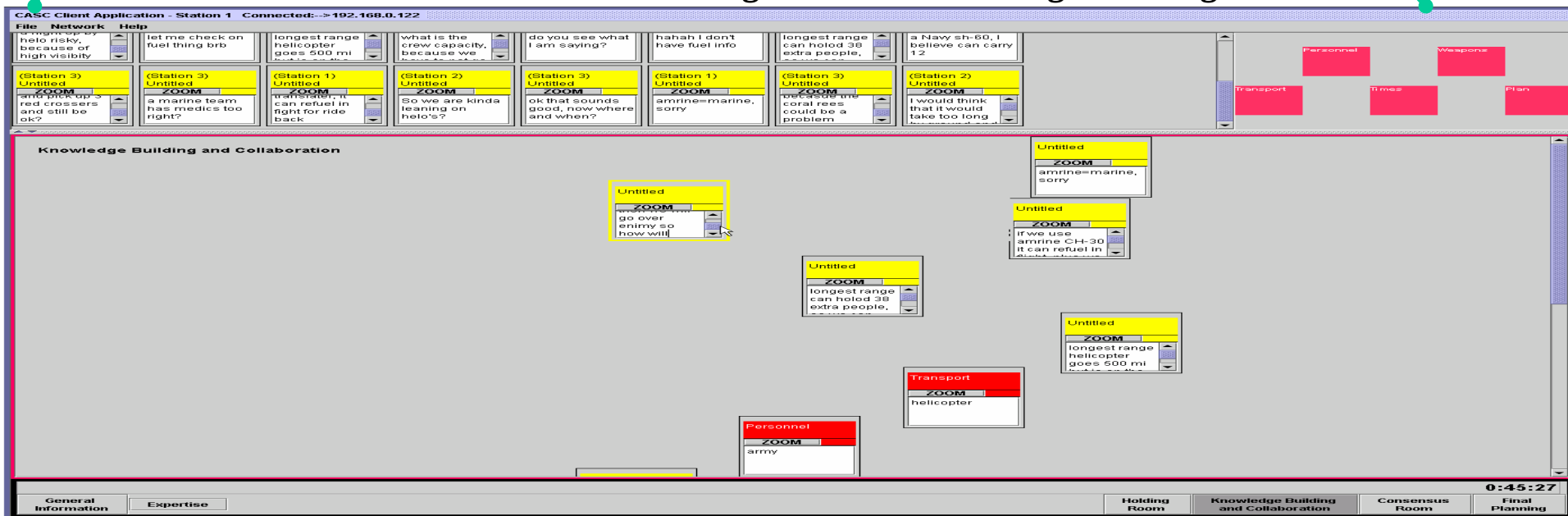
Network Centric Information Grid







Asynchronous, Distributed Ewall Collaboration Tool With Agent Based Knowledge Building Model



CASC POTENTIAL IMPACT

- **Improve total collaborative problem solving time of an Asynchronous, Distributed team to that of a Face-To-Face team. Applicable across different domains (e.g. Network Centric Warfare)**

  *** Asynchronous, Distributed teams are usually an order of magnitude slower than Face-To-Face teams (i.e. from literature and CASC data)**

  *** <u>Improvement achieved through</u>:**

  (1) understanding the collaboration stages and cognitive processes used in Face-To-Face and Asynchronous, Distributed Collaborative teams

  (2) understand the collaboration dynamics between team members (i.e. the transition states for both stages and cognitive processes)

  (3) Using knowledge from (1) & (2) develop an agent-based support system for Asynchronous, Distributed collaborative teams

- **Military impact --- optimize collaborative decision-making activity in asynchronous, distributed teams for mission planning and mission execution**

SCIENTIFIC QUESTIONS ADDRESSED

- **What is the knowledge building process humans use in asynchronous, distributed collaborative problem solving?**

- **What is the effect of the following variables on the knowledge building process during asynchronous, distributed collaboration?**
  - *** Collaboration Modes (face-to-face versus asynchronous, distributed)**
  - *** Knowledge Distribution (homogeneous versus heterogeneous)**
  - *** Knowledge Dynamics (static knowledge versus dynamic knowledge)**

- **What forms of agent support facilitate knowledge building in asynchronous, distributed collaborative problem solving?**

Contribution to Cognitive Science and Collaboration Technology

- Understand the knowledge building process humans use in asynchronous, distributed collaborative problem solving and compare to existing Face-To-Face collaboration literature

- Extend existing collaboration theories to include knowledge building processes for asynchronous, distributed collaborative teams

Face-To-Face Collaboration

OVERVIEW OF PHASE I, II, AND III EXPERIMENTS

- **Phase I Objective = collect empirical data on the collaboration stages and cognitive processes during asynchronous, distributed team collaboration in a collaborative problem solving domain (murder mystery scenario). Emphasis is on the the cognitive processes of knowledge building.**

  - Examine the effects of collaboration mode (face-to-face vs asynchronous, distributed), and knowledge distribution (homogeneous vs heterogeneous)

- **Phase II Objective = building on phase I examine the effects of knowledge dynamics (static vs dynamic knowledge) on the cognitive knowledge building process using the NEO scenario within the Ewall collaboration environment**

- **Phase III Objective = within the context of the revised theory for knowledge building in asynchronous, distributed collaboration (based on Phase I and II results), define and empirically examine the beneficial forms of agent support?**

CASC Phase I Scenario

Murder Mystery

See Appendix A for detail murder mystery information

- **The Case of the Fallen Businessman, (by Dr. Garold Stasser, Miami University, Oxford, Ohio)**
- **<u>Major Characters</u>**

Robert Gill:	**The victim**
Mary Gill:	**The victim's wife**
Lt. Mark Moody:	**Detective in charge of the investigation**
Sgt. Cassini:	**Police officer assisting in the investigation**
****Eddie Sullivan:**	**Handyman who worked for the Gills**
****Billy Prentice:**	**Yardman who worked for the Gills**
****Mickey Malone:**	**Owner of MM Auto Parts; business associate of the victim**
Sam Nietzel:	**Parts manager for Gill Lincoln/Mercury**
Dave Daniels:	**Owner of Dave's Quick Stop in the Eastwood Shopping Center**

**** The <u>ONLY suspects</u> under consideration are: Mickey Malone**
Billy Prentice
Eddie Sullivan

- **<u>Summary</u>: Robert Gill, a prominent local businessman was found dead behind his Crestview home this morning. Detective Lt. Mark Moody of the Hilltown precinct reported that Mr. Gill had apparently been assaulted when leaving his home to play golf early this morning. He was struck on the head over the left eye and fell down a flight of stairs leading from a second story deck at the rear of the house. The preliminary coroner's report concluded that death was caused by injuries sustained from the fall and not from the blow to the head. The report estimated that Mr. Gill's death occurred between 6:30 and 7:00 AM. Lt. Moody would neither confirm nor deny rumors that Mr. Gill had been robbed. "We're following all leads. That's all I have to say for now," said Lt. Moody.**
- **<u>Team Objective</u>: Collaborate on the detailed murder information and develop a team consensus on who killed Mr. Gill**

TECHNICAL PLAN
CASC Phase I Experiment

Independent Variables:

- ***Collaboration Mode*** **(face-to-face vs asynchronous, distributed)**

  *** Face-to-Face = team interacts synchronously with each other through speech**

  *** Asynchronous, Distributed = team interacts with each other at different times and from different locations through a text based web forum**

- ***Knowledge Distribution*** **(homogeneous vs heterogeneous)**

  *** Homogeneous = the members of the team have all the murder mystery knowledge in common**

  *** Heterogeneous = the members of the team have some murder mystery knowledge in common and some uniquely held murder mystery knowledge**

CASC Phase I Experimental Design
(2x2 randomized factorial)

Knowledge Distribution

Collaboration Mode	Homogeneous	Heterogeneous
Face-to-Face (speech)	Gp 1 * * Gp 7	Gp 15 * * Gp 21
Asynchronous, Distributed (text)	Gp 8 * * Gp 14	Gp 22 * * Gp 28

Phase I

- 28 groups total
- 3 subjects / group
- 84 subjects total

Dependent Variables:

- Forum text and face-to-face audio / video recordings including time stamp per response (i.e. text and speech)
- Thinking Aloud Protocol (concurrent verbalizations) for asynchronous, distributed teams
- Total time to successfully complete the problem-solving task (time from the beginning of the task until task completion)
- Collaboration Maps (post session – subjects construct a map of their view of the stages &cognitive process states of team collaboration)
- Subjective Questionnaire – measuring expertise, trust between team members, and general collaboration opinions among members

CASC Phase I Hypotheses

Ho: no significant difference between face-to-face and asynchronous, distributed collaboration modes on the collaboration stages and cognitive knowledge building processes in a collaborative problem solving domain

Ho: no significant difference between homogeneous and heterogeneous knowledge distribution on the collaboration stages and cognitive knowledge building processes in a collaborative problem solving domain

Ho: no significant interaction between collaboration modes and knowledge distribution on the collaboration stages and cognitive knowledge building process

Ho: no significant difference in time or frequency within each cognitive process state across collaboration mode and knowledge distribution conditions

Ho: no convergence of individual mental models with regard to collaboration stages and knowledge building processes

Types of Data Analysis
Phase I, II and III Experiments

- **Verbal Protocol Communication Analyses – identification of collaboration stages and cognitive process states compared across collaboration mode and knowledge distribution. Compare results to preliminary structural model of collaboration.**
- **Transition State Diagrams – representation of the *dynamic* team collaborative behavior between collaboration stages and between cognitive process states within each collaboration stage compared across collaboration mode and knowledge distribution. Compare results to preliminary structural model of collaboration.**
- **Parametric statistics – for analyzing time, and frequency within each collaboration stage and cognitive process state across collaboration mode and knowledge distribution conditions. Also used for analyzing total time to complete task and questionnaire data.**
- **Collaboration Maps – determine the degree of convergence between individual mental model 's regarding collaboration stages and cognitive processes. In addition, compare how an individual thinks a group makes a decision in a collaborative setting and how the group actually performs.**

CASC Phase I Experiment

Face-to-Face, Homogeneous Team Collaboration Example (shows card sorting approach to information management)

CASC Phase I Experiment

Face-to-Face, Homogeneous Team Collaboration Example

(shows using maps to transfer meaning to team members)

CASC PHASE I EXPERIMENT

Asynchronous, Distributed, Homogeneous Team Example

Using Forum Collaboration Environment

Crew Systems Collaboration Research

Welcome to the Crew Systems asynchronous collaboration research page. If you are not a moderator, administrator, or subject in these experiments, leave immediately. You're IP address has been logged, and you have illegally accessed a military computer.

Post a reply

Subject

Message body

B i u Quote Code List List= Img URL

Font colour: Default Font size: Normal Close Tags

Tip: Styles can be applied quickly to selected text

who do you guys think mu

Options
HTML is OFF
BBCode is OFF
Smilies are OFF

Notify me when a reply is posted

Add an Attachment

If you do not want to add an attachment to your post leave the fields blank

Filename Browse...

File Comment Add Attachment

Preview Submit

All times are EST (U.S./Canada)

Jump to: Select a forum Go

Topic review

Author	Message

MODEL EVOLUTION OF TEAM COLLABORATION

INITIAL THEORY FOR ACHIEVING COLLABORATIVE KNOWLEDGE IN ASYNCHRONOUS COLLABORATION

TEAMWISE COLLABORATION MODEL (Rawlings,2000)
- interplay between interdependent tasks and team
- req. conditions = shared purpose / vision, efficient collaborative work / capability to achieve goals

Time, Interaction and Performance (TIP) propositions (McGrath, 1991):
- Nature of groups
- Temporal factors
- Group interaction process

KNOWLEDGE BUILDING PROCESS (Stahl, 2000)

ARROWS = TRANSFORMATIVE PROCESSES — RECTANGLES = FORMS OF KNOWLEDGE

Collaborative knowledge → Formalize & objectify → Use in performing task → Update personal understanding → personal understanding → Articulate in words → other people's statements (i.e. Team) → Discuss alternatives → argumentation & rationale → Clarify meanings → shared understanding → Negotiate perspectives → Collaborative knowledge

METRICS

Collaboration
- information rich group discussions
- collective decision making
- integrated, joint solutions derived from group

Knowledge Building Process
- Thinking Aloud Protocol (verbalize)
- Concept Map (pre / post session)
- Percentage of Domain Relevant Information exchanged (verbal / text protocol analyses)
- Number of Integrated, Joint Solutions
- Time to successfully complete common task

Preliminary Conceptual Model of Collaboration

Level 1 (Stages)

Team Orientation
- getting acquainted
- clarifying task
- initial attitudes

Team Conflict
- decision alternatives
- criticism of alternatives

Emergence of Team Decisions
- decisions emerge from team

Reinforcement of Team Decisions
- team consensus

Model

Level 2 (Processes)

Individual Understanding ⇄ Articulate to Team ⇄ Accumulation of facts (Team)

Select & Discuss → • Decision Alternatives • Criticism of Alternatives (with rationale)

Negotiate Perspectives of alternatives → Collaborative Knowledge

Establish → Team Shared Understanding

Achieve → Team Consensus

Iteration loop for selecting decision alternatives

Update

Implement Decision To Solve Task

□ = Knowledge Building

STRUCTURAL MODEL OF TEAM COLLABORATION

Problem Area Characteristics

Collaborative Situation Parameters:
- time pressure
- information/knowledge uncertainty
- dynamic information
- large amount of knowledge (cognitive overload)
- human-agent interface complexity

Team Types
- asynchronous
- distributed
- culturally diverse
- heterogeneous knowledge
- unique roles
- command structure (hierarchical vs. flat)
- rotating team members

Operational Tasks
- team decision making, COA selection
- develop shared understanding
- intelligence analysis (team data processing)

Collaboration Stages

Team Knowledge Base Construction → Collaborative Team Problem Solving → Team Consensus → Outcome Evaluation and Revision → Collaboration Complete? Yes: Achieve Goal; No: ↑

Meta-Cognitive:
- individual understanding of problem conditions
- individual mental model development of situational significance
- goal development
- team mental model of problem
- team plan to solve problem
- track team's mental model changes
- understanding remaining items to resolve
- compare problem solution against goals

Information Processing:
- problem identification
- understanding problem task
- establish team communication and trust
- establish data filtering methods
- establish meaning transfer conventions
- goal definition
- iterative information collection & analysis
- develop, rationalize, & visualize solution alternatives
- team negotiation of solution alternatives
- analyze, revise output

Knowledge Building:
- problem definition
- individual task knowledge
- individual team knowledge
- team mental model of team
- team task knowledge
- domain expertise
- shared understanding
- collaborative knowledge
- collaborative knowledge
- shared understanding
- goal requirements
- exit criteria

Communication Mechanism for Information Processing and Knowledge Building (applies to all stages):
- presenting individual information
- disagreement
- questioning
- discussing individual information
- negotiating perspectives
- discussion of possible solutions
- discussing team generated information
- providing rationale for individual solutions
- agreement

STRUCTURAL MODEL OF TEAM COLLABORATION

Problem Area Characteristics

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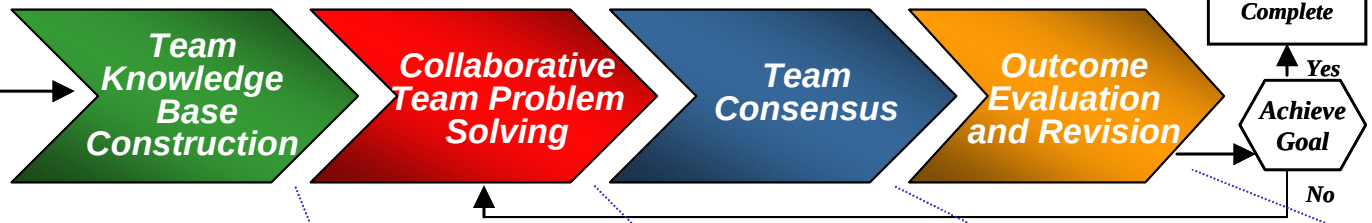
Collaboration Stages



	Team Knowledge Base Construction	Collaborative Team Problem Solving	Team Consensus	Outcome Evaluation and Revision
Meta-Cognitive:	• individual understanding of problem conditions • individual mental model development of situational significance	• goal development • team mental model of problem • team plan to solve problem	• track team's mental model changes • understanding remaining items to resolve	• compare problem solution against goals
Information Processing:	• problem identification • understanding problem task • establish team communication and trust • establish data filtering methods • establish meaning transfer conventions	• goal definition • iterative information collection & analysis • develop, rationalize, & visualize solution alternatives	• team negotiation of solution alternatives	• analyze, revise output
Knowledge Building:	• problem definition • individual task knowledge • individual team knowledge	• team mental model of team • team task knowledge • domain expertise • shared understanding • collaborative knowledge	• collaborative knowledge • shared understanding	• goal requirements • exit criteria

Communication Mechanism for Information Processing and Knowledge Building (applies to all stages):

• presenting individual information • disagreement • questioning	• discussing individual information • negotiating perspectives • discussion of possible solutions	• discussing team generated information • providing rationale for individual solutions • agreement

CASC Phase I Collaboration Stages Coding Definitions

(see Appendix B for complete list of examples)

- **Team Knowledge Base Construction (TK): "Team members reading, clarifying information and understanding the problem."**

  * Defining the problem (realizing what they have to accomplish --- "We need to come up with a solution in 30 minutes.")
  * Clarifying the facts --- "What did they say about Joe's hearing?

- **Collaborative Team Problem Solving (TPS): "Team members working together to develop solution options to the problem."**

  * Analyzing the facts to come up with a solution - - - "I think Joe did it because he tried to blame everything on Tim."

- **Team Consensus (TC): "Team negotiation of solution option and final agreement by all team members on a particular option."**

  * Agreeing on the final solution - - - "Do we all agree that Joe did it?"

- **Outcome Evaluation & Revision (OER): "Team evaluation of selected solution option against problem solving goal. Team revises solution option if option does not meet goal."**

  * Choosing to accept the final decision or revise it - - - "I know we all agreed on Tim, but I think we better take a closer look at Joe."

- **Additional Stages (MISC): "Other unique team behavior not described in the above categories."**

  * Need to describe unique behavior and label stage.

CASC Phase I Cognitive Process States Coding Definitions

(see Appendix B for complete list of examples)

<u>Team Knowledge Base Construction</u>: (TK) "Team members reading clarifying and understanding the problem to be solved."

IPup: Information Processing (understanding problem) = stating the facts without applying that knowledge to any possible solution.

"Tim's muffler was loud"

IPgd: Information Processing (goal definition) = defining the team goal.

"Our goal is to determine who killed Mr. Gill"

IPct: Information Processing (communication & trust) = establishing team trust.

"I understand why you thought it was Tim."

IPdfm: Information Processing (data filtering methods) = team uses methods to sort data.

"using yellow note pads to sort data into categories"

IPtck: Information Processing (transfer conventions) = team uses methods to transfer meaning to other team members during knowledge construction.

"team uses map of Mr. Gill's house to understand distances between objects.

KBpd: Knowledge Building (problem definition) = defining the problem (realizing what they have to accomplish)

"We need to come up with a solution in 30 minutes"

KBik: Knowledge Building (indiv. knowledge) = <u>individual</u> clarifying the facts; asking for clarification.

"What did they say about Joe's hearing"

KBtk: Knowledge Building (team knowledge) = <u>team</u> clarifying facts

"Billy left the coffee shop at 7:00am"

"No that was Eddie that left the coffee shop at 7:00am

"Yes that was Eddie"

CASC Phase I Cognitive Process States Coding Definitions

(see Appendix B for complete list of examples)

Collaborative Team Problem Solving: (TPS) "Team members working together to develop solution options to the problem."

MCtp: Meta-cognitive (team plan) = establishing a plan of approach.

"ADHES 2, why don't you say who you think it is, then I'll say who I think it is."

IPica: Information Processing (information collection & analysis) = collecting and analyzing the facts to come up with a solution but no specific solution mentioned.

"The killer seems to blame everything on Tim."

IPtcp: Information Processing (transfer conventions) = team uses methods to transfer meaning to other team members during team problem solving.

" Using maps or yellow stickers to transfer meaning to team members"

IPsa: Information Processing (solution alternatives) = developing, rationalizing and discussing solution alternatives.

"I think Eddie did it?"

KBde: Knowledge Building (domain expertise) = team members state their own domain knowledge and apply that knowledge to the problem.

"Yes I am a Maryland State Trooper and they is no concrete evidence for Billy killing Mr. Gill."

KBsu: Knowledge Building (shared understanding) = using facts to justify a solution.

"I think Eddie did it because he was hard of hearing and had his fingerprints on the crowbar."

KBck: Knowledge Building (collaborative knowledge) = Convincing others of a specific thought without absolute consensus of the final solution.

"You're right. I didn't think about that."

CASC Phase I Cognitive Process States Coding Definitions

(see Appendix B for complete list of examples)

Team Consensus: (TC) "Team negotiation of solution option and final agreement by all team members on a particular option."

MCitr: Meta-cognitive (items to resolve) = team stating remaining items to resolve.

"We need to compare Mickey's and Eddie's location times with Billy's"

IPtn: Information Processing (team negotiation) = team negotiation of solution alternatives ending in a final solution.

" I believe it is Eddie because he was hard of hearing"

" I concur which also means Eddie was lying about where is was"

"I also think it was Eddie because of his fingerprints on the crowbar.

"We all in consensus, it was Eddie"

KBckc: Knowledge Building (collaborative knowledge) = convincing others of a specific thought without absolute consensus of the final solution.

"You're right. I didn't think about that."

KBsuc: Knowledge Building (shared understanding) = using facts to justify a solution.

"It couldn't have been Tim because his muffler was loud and the car at the coffee shop had a quiet muffler."

CASC Phase I Cognitive Process States Coding Definitions

(see Appendix B for complete list of examples)

Outcome Evaluation & Revision: (OER) "Team evaluation of selected solution option against problem solving goal. Team revises solution option if option does not meet goal."

MCps: Meta-cognitive (problem solution) = compare problem solution against goal(s).

"Are we done or do we want to talk about it some more?"

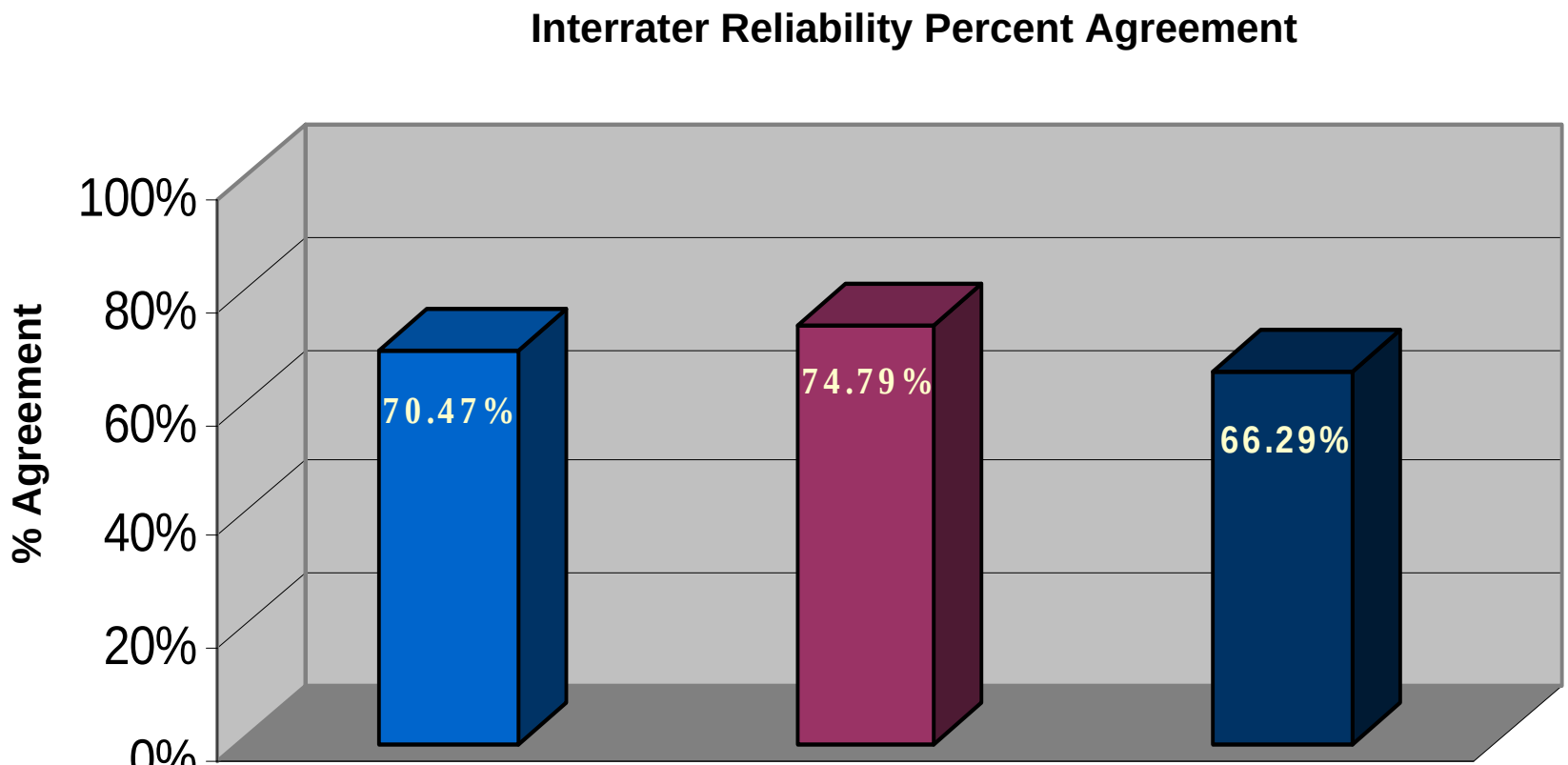
IPar: Information Processing (analyze, revise output) = analyze final solution option and revise if necessary.

"I know we all agreed on Tim, but I think we'd better take a closer look at Joe."

KBgo: Knowledge Building (goal obtainment) = understand if solution option fits specific goal criteria.

" the murder had a truck with a loud muffler, was at Mr. Gills house around 10:30am, and pushed Mr. Gill down the porch steps".

CASC Phase I Results



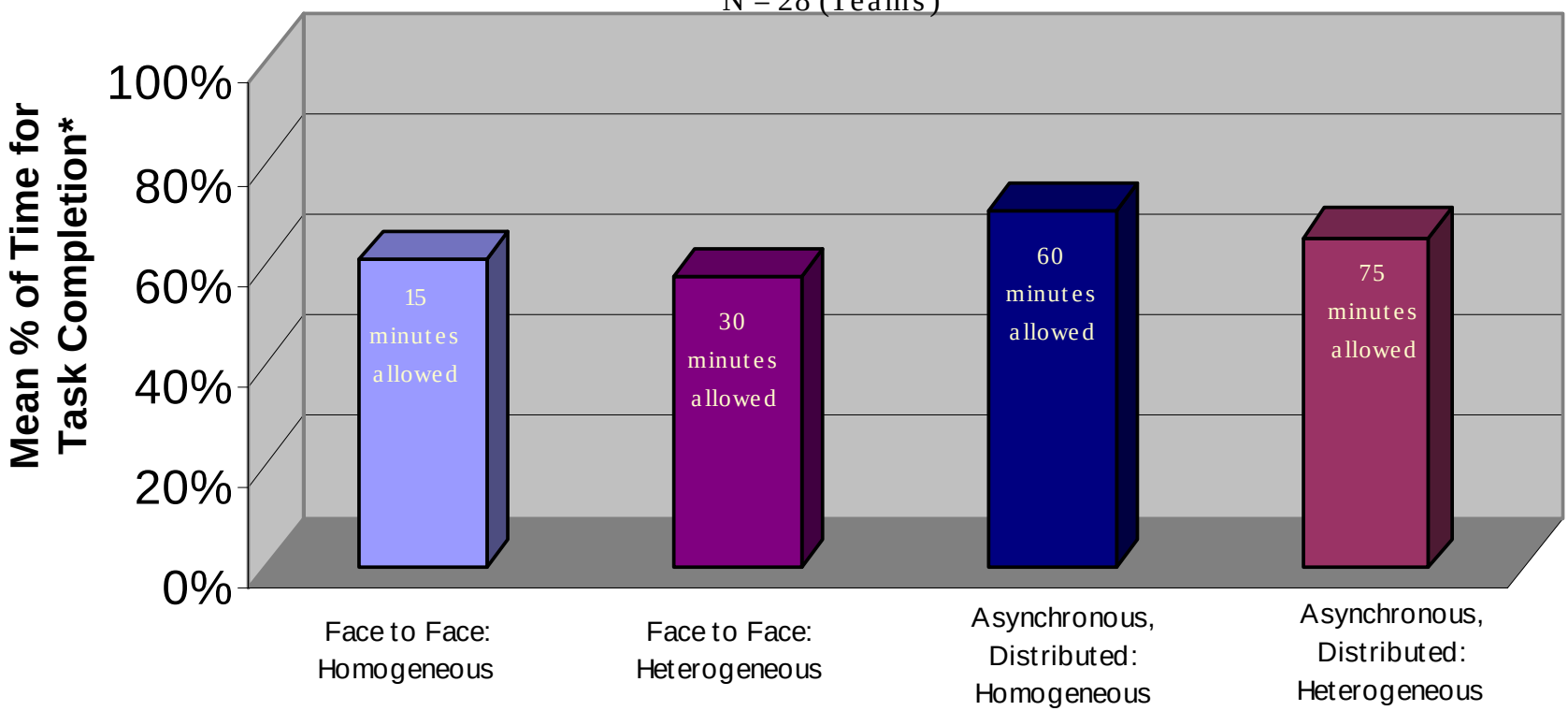
CASC Phase I Results

Mean % of Time for Task Completion by Collaboration Mode & Knowledge Distribution

CM: F = 0.6406, p = 0.431353 KD: F = 0.1491, p = 0.702782

CM*KD: F = 0.0006, p = 0.933647

N = 28 (Teams)



•Team time = utterance time for each team Divided by time allowed for each team

Collaboration Mode vs. Knowledge Distribution

CASC Phase I Results

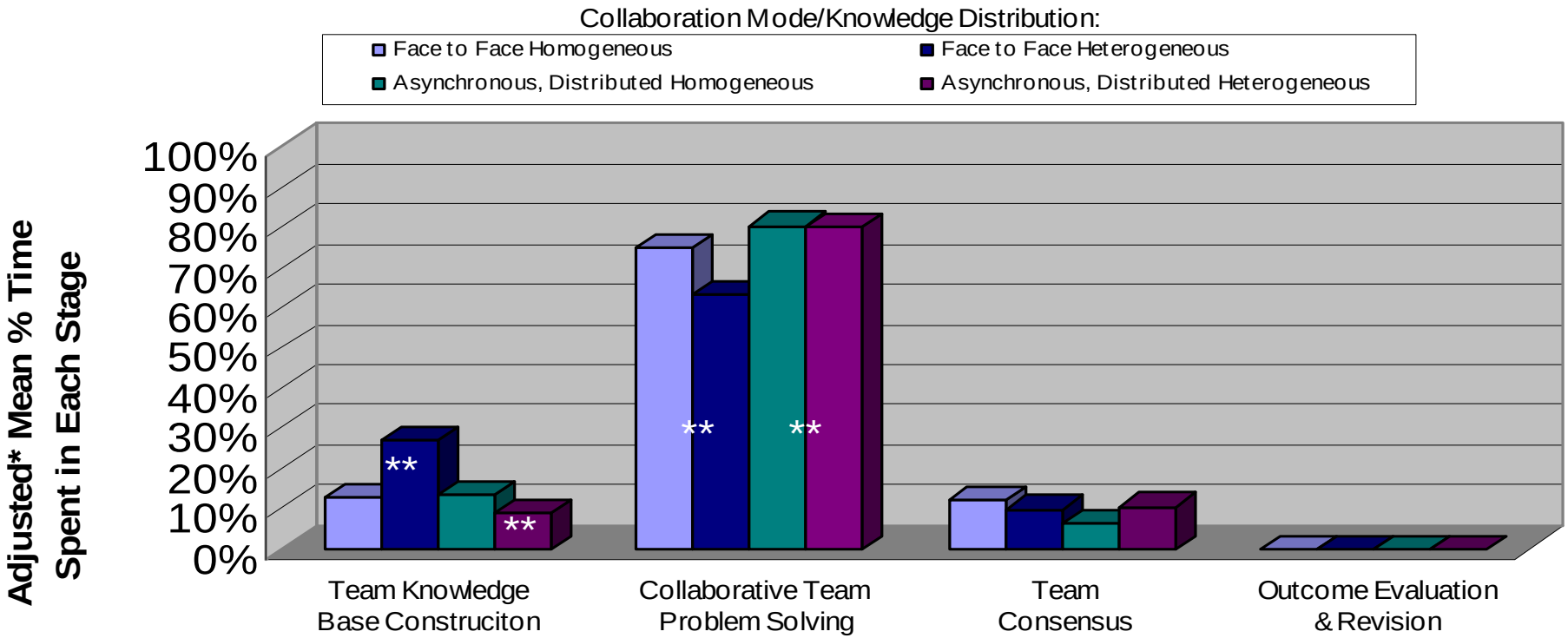
Mean % Time by Collaboration Stages

Collaboration Mode (CM) vs. Knowledge Distribution (KD)

Team Knowledge Base Construction:
CM: F = 5.51323, p = 0.027449
KD: F = 170682, p = 0.203780
CM*KD: F = 6.02627, p = 0.021724
N = 84

Collaborative Team Problem Solving:
CM: F = 6.944, p = 0.014504
KD: F = 2.010, p = 0.169097
CM*KD: F = 1876, p = 0.183471
N = 84

Team Consensus:
CM: F = 0.51854, p = 0.478422
KD: F = 3.43855, p = 0.07602
CM*KD: F = 0.82967, p = 0.371425
N = 84

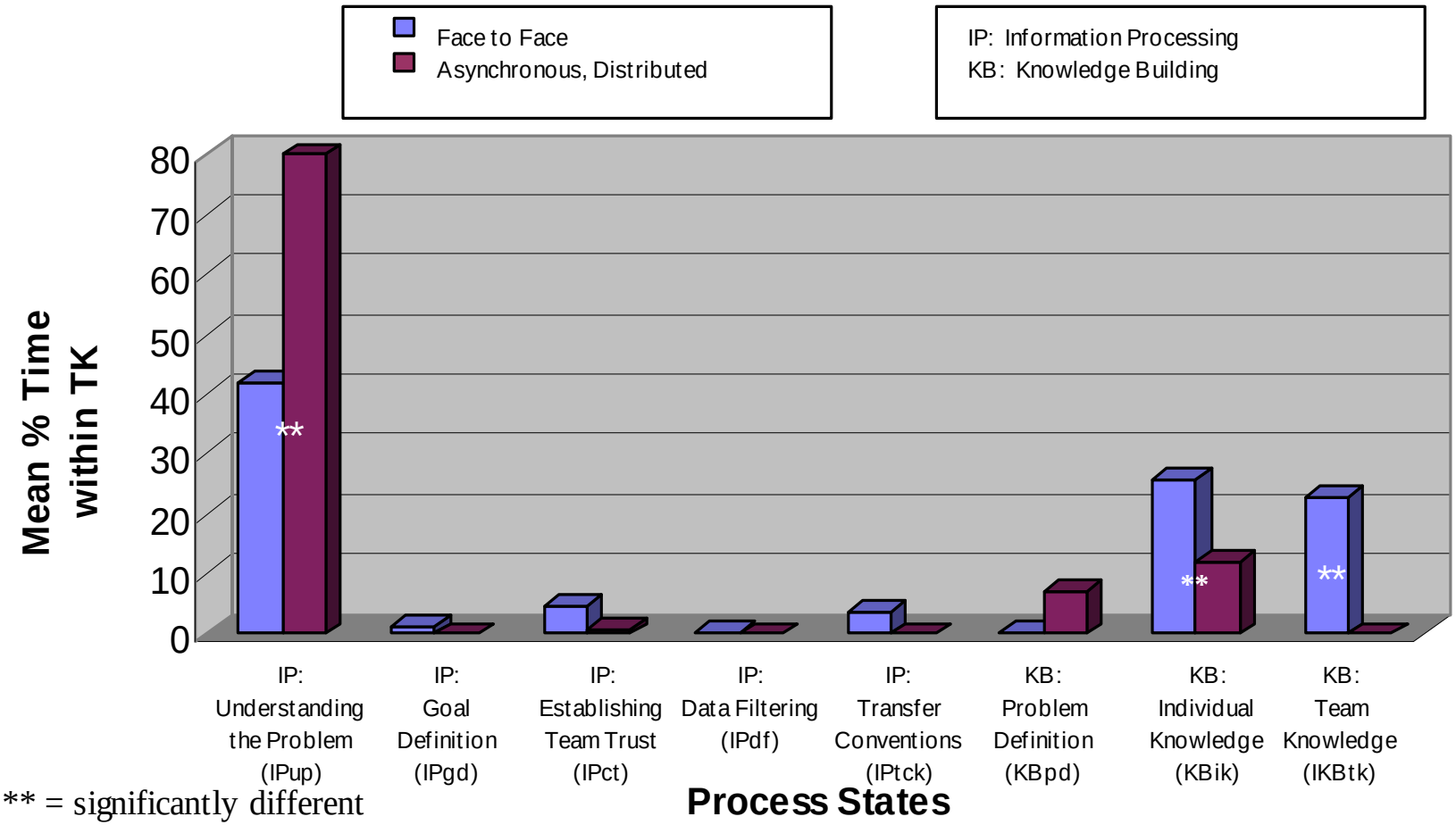


** = significantly different

*Adjusted: Each team's time per stage was calculated by dividing the utterance time for each stage by the total utterance time for the team.

Mean % Time By Cognitive Process States: Team Knowledge Construction (TK)

Wilks lambda = 0.402182, F = 3.158681, p = 0.022010



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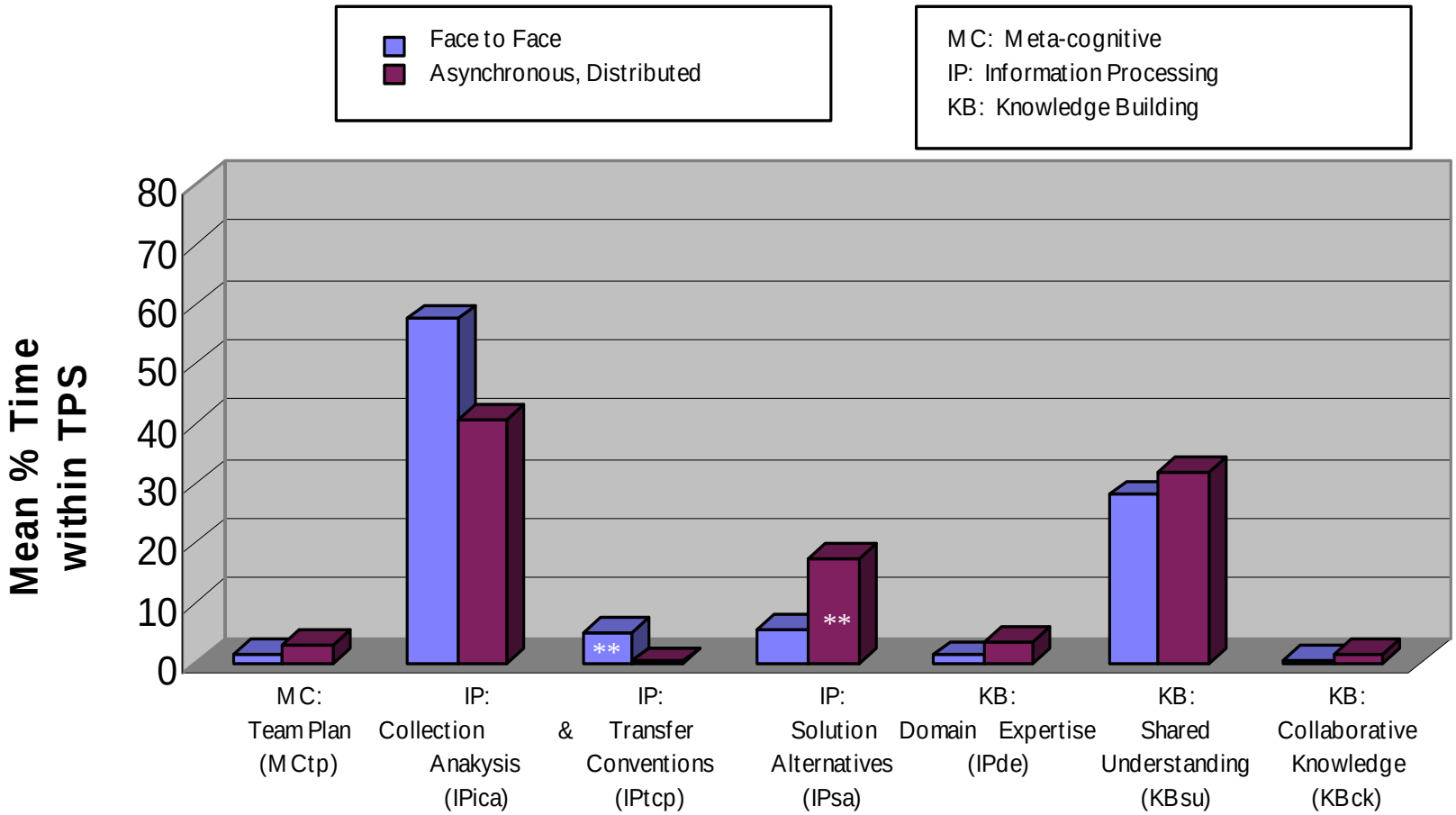
Mean % Time By Cognitive Process States: Collaborative Team Problem Solving (TPS)

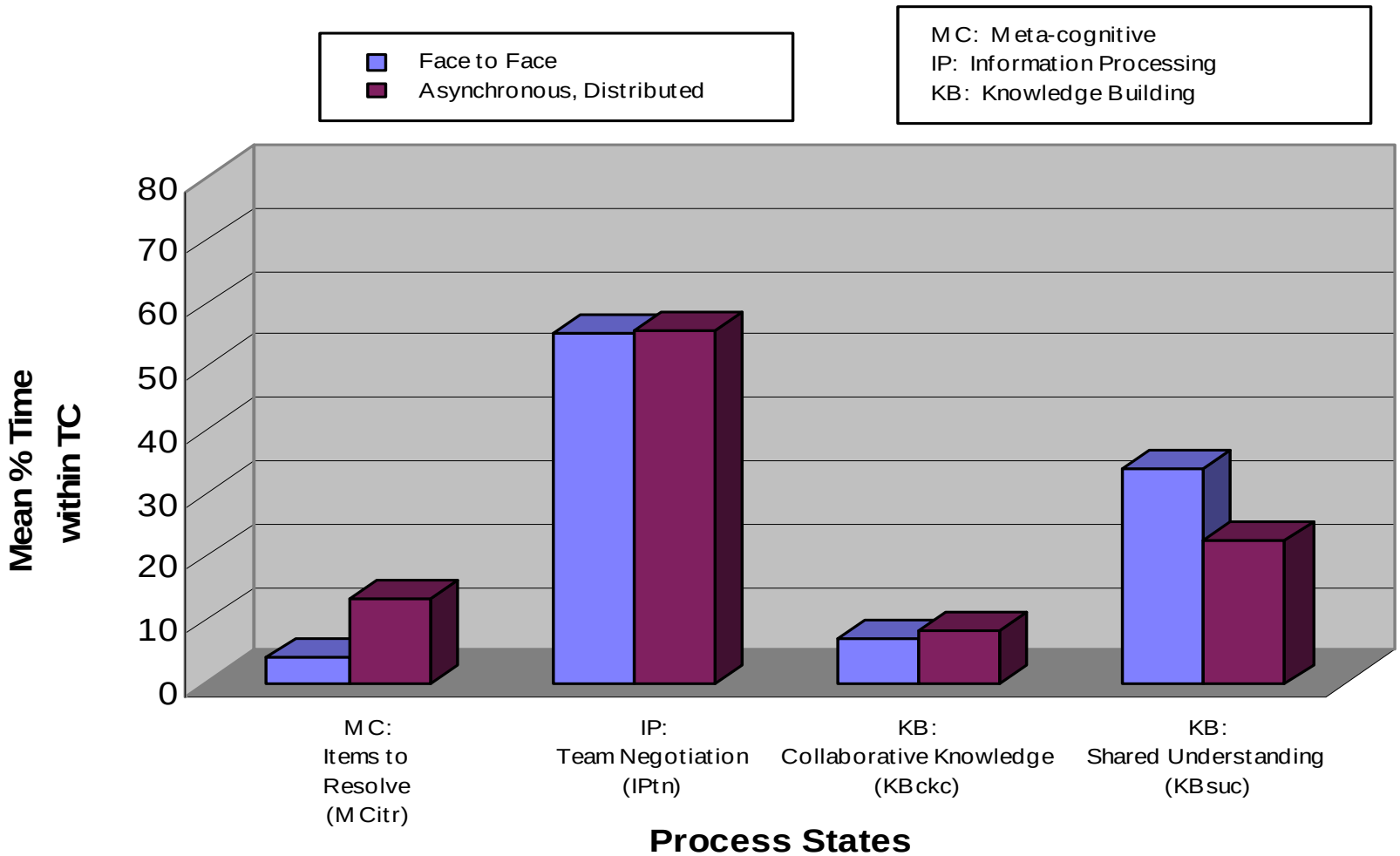
Wilks lambda = 0.00033 F = 9605.498 p = 0.000000



** = significantly different

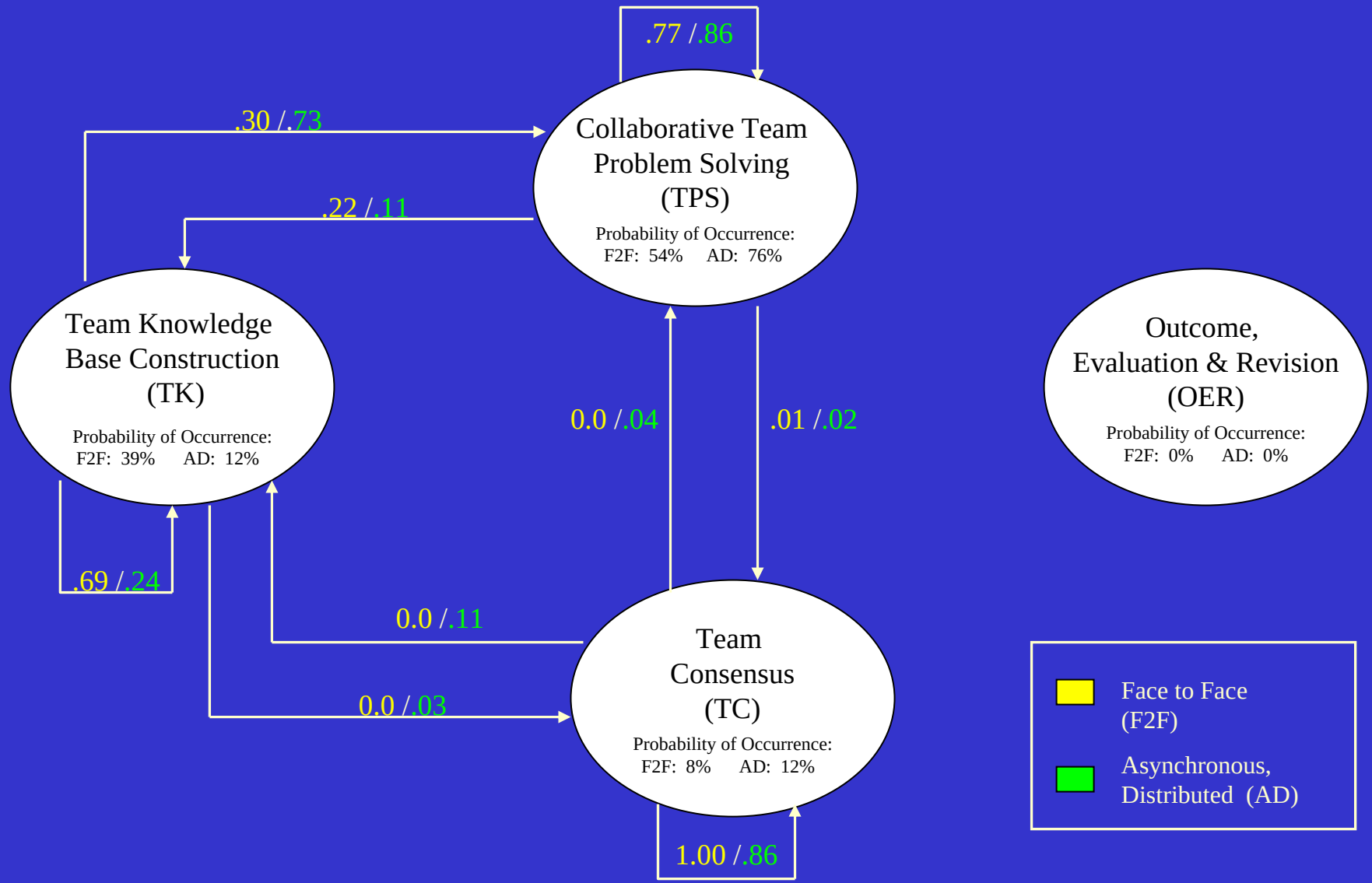
Mean % Time By Cognitive Process States: Team Consensus (TC)

Wilks lambda = 0.815855, F = 1.65519, p = 0.205648

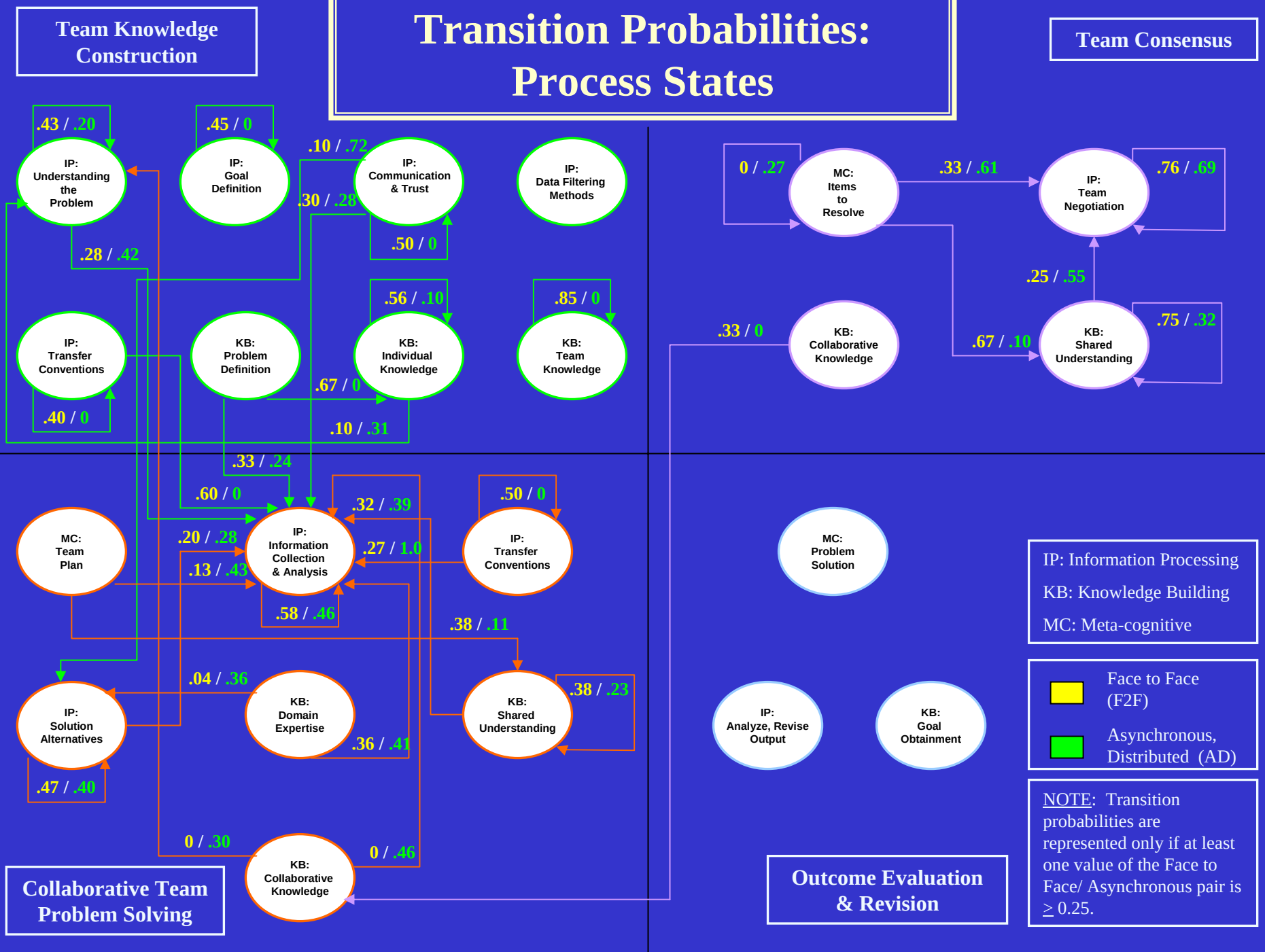


** = significantly different

Transition Probabilities: Collaboration Stages



Transition Probabilities: Process States



CASC Phase I Conclusions

Collaboration Stages

- **Face-to-Face heterogeneous teams spend significantly more time in team knowledge construction than asynchronous, distributed heterogeneous teams. There was no difference between the homogeneous teams.**

- **Asynchronous, distributed teams spend more time in the collaborative problem solving stage than face-to-face teams. There was no difference between homogeneous and heterogeneous teams with regard to time spent in the collaborative problem solving stage.**

- **There was no difference in the amount of time spent in team consensus and outcome evaluation & revision stages between collaboration mode and knowledge distribution conditions**

CASC Phase I Conclusions

Cognitive Process States

- In team knowledge base construction (TK) the face-to-face teams spend significantly more time developing individual knowledge and team knowledge than the asynchronous, distributed teams. Asynchronous, distributed teams spend significantly more time understanding the problem compared to Face-to-Face teams.

- In collaborative team problem solving (TPS) the face-to-face teams spend significantly more time in using conventions to transfer meaning compared to asynchronous, distributed teams. Asynchronous, distributed teams spend significantly more time developing solution alternatives compared to Face-to-Face teams.

- In team consensus (TC) there were no significant differences between Face-to-Face and Asynchronous, Distributed teams in team consensus process states.

CASC Phase I Conclusions
Transition Probabilities and Paths

- **Both face-to-face and asynchronous, distributed teams demonstrated dynamic transitions between Team Knowledge Base Construction (TK), Collaborative Problem Solving,(TPS) and Team Consensus stages (TC). Outcome Evaluation & Revision stage was not used by either team type because there was no need to revise given our domain task.**
  - *** Face-to-face teams demonstrated mostly a linear path between TK, TPS and TC whereas asynchronous, distributed teams showed non-linear path with feedback loops (area for agent support)**

- **During team knowledge base construction(TK) face-to-face teams demonstrated more transitions between the TK cognitive process states than the asynchronous, distributed teams. Transition probabilities for the face-to-face teams were higher in most cases compared to the asynchronous, distributed teams**
- **During collaborative team problem solving (TPS) both team types focused on the information collection and analysis process state (IPica). Also, the IPica state was the main transition state from the TK stage.**

CASC Phase I Conclusions

Transition Probabilities and Paths (continued)

- During team consensus both team types showed dynamic transitions between the process states of team negotiation and shared understanding. Low probability of transition back to cognitive process states within Team Problem Solving or Team Knowledge Construction stages

- No dynamic transitions into the cognitive process states of the Outcome Evaluation & Revision stage by either team type

Phase II Experiment

- **Collaboration Task:**
  - **Expanded NEO Mission Scenario (Warner, Wroblewski, Schuck, Cowen, Letsky, 2003)**
    - *** see Appendix C for detail scenario**
    - *** developed with expertise from operational personnel (Navy Seal, Marine, Army aircrew)**

  - **Mission Statement ---**

    The time is 2:00am, January 15. Your mission is to rescue 3 stranded Red Cross workers from a church basement, on a remote island, caught in the middle of guerilla warfare, within 24 hours. The situation is described in the next few pages along with the assets of US forces which are available to rescue the workers. You need to work together and develop a course of action (using ANY assets available to you), which includes a plan for getting to the church, a plan for evacuating the workers, and a plan for the return to the Army base or aircraft carrier. The course of action solution can be an Army, Marine, Navy Seals solution, or a combination of the assets of the three. You want to choose the optimal and most efficient solution. You want to minimize damage to the village and villagers; you want to avoid contact with enemy if possible, and to rescue the workers safely. However, the rules of engagement are that any forces will defend themselves if needed. Good Luck!

- **Asynchronous, Distributed Collaboration Environment:**
  - **Modified Ewall workstation and visualization area**
    - *** see Appendix D for design specification for Ewall modifications**
    - *** see next four slides for modified Ewall workstation display**

CASC Client Application - Station 1 Connected:-->192.168.0.122

File Network Help

helo risky, because of high visibity

let me check on fuel thing brb

longest range helicopter goes 500 mi

what is the crew capacity, because we

do you see what I am saying?

hahah I don't have fuel info

longest range can holod 38 extra people,

a Navy sh-60, I believe can carry 12

(Station 3) Untitled ZOOM and pick up 3 red crossers and still be ok?

(Station 3) Untitled ZOOM a marine team has medics too right?

(Station 1) Untitled ZOOM translater, it can refuel in fight for ride back

(Station 2) Untitled ZOOM So we are kinda leaning on helo's?

(Station 3) Untitled ZOOM ok that sounds good, now where and when?

(Station 1) Untitled ZOOM amrine=marine, sorry

(Station 3) Untitled ZOOM becasue the coral rees could be a problem

(Station 2) Untitled ZOOM I would think that it would take too long

Personnel Weapons Transport Times Plan

Knowledge Building and Collaboration

Untitled ZOOM go over enimy so how will

Untitled ZOOM amrine=marine, sorry

Untitled ZOOM if we use amrine CH-30 it can refuel in

Untitled ZOOM longest range can holod 38 extra people,

Untitled ZOOM longest range helicopter goes 500 mi

Transport ZOOM helicopter

Personnel ZOOM army

0:45:27

General Information | Expertise | Holding Room | Knowledge Building and Collaboration | Consensus Room | Final Planning

CASC Client Application - Station 2 Connected:-->192.168.0.122

File Network Help

(Station 1) Untitled ZOOM: The water temperature is 84o F.

(Station 1) Untitled ZOOM: The waters around Drapo are a

(Station 1) Water Rescue ZOOM: They shouldn't be too cold if they go by the water

(Station 1) Untitled ZOOM: The water temperature is 84o F.

(Station 1) Untitled ZOOM: The water temperature is 84o F.

(Station 1) Water Rescue ZOOM: They shouldn't be too cold if they go by the water

(Station 1) Untitled ZOOM: The waters around Drapo are a

(Station 1) Untitled ZOOM: I still think we should fly over the mountains

(Station 1) Untitled ZOOM

(Station 1) Untitled ZOOM

(Station 1) Untitled ZOOM

(Station 1) Untitled ZOOM

(Station 1) Untitled ZOOM

(Station 1) Untitled ZOOM

(Station 1) Untitled ZOOM

(Station 1) Untitled ZOOM

Personnel

Weapons

Transport

Times

Plan

Holding Room

(Station 1) Untitled ZOOM: So, who do you think we should use?

(Station 1) Untitled ZOOM: Personally, I'm leaning more

(Station 1) Untitled ZOOM: I don't know. WHat do you think?

(Station 2) Untitled ZOOM: I'm not sure.

(Station 2) Untitled ZOOM: I'm thinking maybe the Navy

(Station 2) Untitled ZOOM: The time is 2:00 am, January 15th.

(Station 2) Untitled ZOOM: The island is 400 miles wide by 400

(Station 2) Untitled ZOOM: Suppressive fire by aircraft can be used

(Station 1) Untitled ZOOM: That's true... but are you sure you

(Station 1) Untitled ZOOM: Choose the best and most efficient

(Station 1) Untitled ZOOM: The water temperature is 84o F.

(Station 1) Water Rescue ZOOM: They shouldn't be too cold if

1:16:43

General Information | Expertise | Holding Room | Knowledge Building and Collaboration | Consensus Room | Final Planning

CASC Client Application - Station 1 Connected:-->192.168.0.122

File Network Help

with them a seal team on each bird

we take a translater in case or won't we need him?

Army base is too far, so how about 2 seahawks?

i supose we sould send them out right

seahawks? what are they

when is the moon not its brightest?

black hawks with navy seals?

sorry, I meant SH 60

(Station 1) Untitled ZOOM
we wont be flying over enimy, we will

(Station 3) Untitled ZOOM
SH 60 is the same helo as a blackhawk, just Navy

(Station 1) Untitled ZOOM
ok, does the same things then fine

(Station 3) Untitled ZOOM
we want blackhawks from Army base??nright

(Station 1) Untitled ZOOM
yeah, with navt seals on board i guess

(Station 3) Untitled ZOOM
ok

(Station 3) Untitled ZOOM
ok to the consensus room?

(Station 1) Untitled ZOOM
writing on final plan what we know?

Personnel
Weapons
Transport
Times
Plan

Consensus Room

Station 1

Personnel ZOOM
army

Transport ZOOM
black hawk

Times ZOOM
leave base at 3am twards church

Plan ZOOM
refue in flight on way back

Station 3

Transport ZOOM
2 UH 60 blackhawks

Station 2

Transport ZOOM
sh-60, I agree

Times ZOOM
3am

0:21:30

General Information | Expertise | Holding Room | Knowledge Building and Collaboration | Consensus Room | Final Planning

CASC Client Application - Station 1 Connected:-->192.168.0.122

File Network Help

I think so	9pm would be better, helo goes 184m/hr	this before the sun comes up today	prep...manpower wise you know?	Are we still refuling on way back?	ok, how many miles from base to church?	sunrise is at 6am..so 5 would be too late	yes on refule Q
(Station 3) Untitled ZOOM yes refueling	(Station 3) Untitled ZOOM y'all decide on time, I just don't hink day	(Station 1) Untitled ZOOM well it's either 3am (night) or 9pm (night)	(Station 1) Untitled ZOOM put for wepons, riflemen	(Station 3) Untitled ZOOM	(Station 2) Untitled ZOOM lets stick with the arrive 3 am	(Station 3) Untitled ZOOM sorry, how many seals g	(Station 3) Untitled ZOOM sorry, how many seals go in the church

Personnel Weapons Transport Times Plan

Final Planning Room

Personnel	Transportation	Weapons	Critical Times	Detailed Plan	Additional Comments
2 teams of SEALS	2 uh-60 Blackhawks		Onset: 2:15 am Contact: 3:00 am Evacuation: 3:30 am Return: 4:15 am	Fly to church pick up red cross workers and refueling on way back	

Final Submission

Untitled ZOOM times are wrong, we can't start at 2, it's

0:03:13

General Information | Expertise | Holding Room | Knowledge Building and Collaboration | Consensus Room | Final Planning

Phase II Experiment
FY04 Plans

Independent Variables:

- ***Collaboration Mode*** **(face-to-face vs asynchronous, distributed)**

  * **Face-to-Face = team interacts synchronously with each other through speech**

  * **Asynchronous, Distributed = team interacts with each other at different times and from different locations through the Ewall collaboration environment**

- ***Knowledge Dynamics*** **(static vs dynamic knowledge)**

  * **static knowledge = all information (I.e. background information, rebels, Navy Seals, Marine and Army assets, Intell, weapons and environment expertise information) remains the same throughout the collaborative NEO scenario problem**

  * **dynamic knowledge = Selected information (I.e. rebels, weather, time to rescue, condition of red cross workers) changes at a standard time in the collaborative NEO scenario problem**

CASC PHASE II EXPERIMENTAL DESIGN

(2x2 randomized factorial)

Knowledge Dynamics

Collaboration Mode	Static	Dynamic
Face-to-Face (speech)	Gp 1 * * Gp 8	Gp 17 * * Gp 24
Asynchronous, Distributed (Ewall –text, pictures)	Gp 9 * * Gp 16	Gp 25 * * Gp 32

Phase II

- 32 groups total
- 3 subjects / group
- 96 subjects total

Dependent Variables:

Ewall cards and face-to-face audio / video recordings including time stamp per response (i.e. cards and speech)

- **Total time to successfully complete the problem-solving task (time from the beginning of the task until task completion)**
- **Collaboration Maps (post session – subjects construct a map of their view of the stages & cognitive process states of team collaboration)**
- **Subjective Questionnaire – measuring expertise, trust between team members, and general collaboration opinions among members**

CASC PHASE II HYPOTHESES

Ho: no significant difference between face-to-face and asynchronous, distributed collaboration modes on the collaboration stages and cognitive knowledge building processes in the NEO collaborative problem domain

Ho: no significant difference between static and dynamic knowledge on the collaboration stages and cognitive knowledge building processes in the NEO collaborative problem domain.

Ho: no significant interaction between collaboration modes and knowledge dynamics on the collaboration stages and cognitive knowledge building process

Ho: no significant difference in time or frequency within each cognitive process state across collaboration mode and knowledge dynamic conditions

Ho: no convergence of individual mental models with regard to collaboration stages and knowledge building processes

Accomplishments

- **Development of a Structural Model Of Team Collaboration**
  - Describes team collaboration emphasizing the cognitive aspects of the collaboration process.
  - The model includes the domain characteristics, collaboration stages, meta-cognitive processes, information processing tasks, knowledge required for each information processing task and the communication mechanisms for knowledge building and information processing tasks.
  - Starting point for understanding the cognitive mechanisms of team collaboration
  - Offers a model-based approach to experimentation of team collaboration
  - Identifies and prioritizes important areas of research in team collaboration
  - Serves as a design guideline for an agent-based support tool for team collaboration.

- **CASC Phase I Collaboration Experiment**
  - Examined the collaboration stages and cognitive processes used by face-to-face versus asynchronous, distributed teams in a collaborative problem solving task.

- **Transition of Structural Model of Team Collaboration to Naval Air Systems Command Network Centric Warfare Simulation Facility**
  - Collaboration model is currently being transitioned into the newly developed Naval Air Systems Command Network Centric Warfare Simulation Facility to improve collaboration between Commanders both at the front end (e.g. mission planning), and during mission execution
  - The Naval Air Systems Command Network Centric Simulation Facility represents connectivity between all the relevant assets in a Network Centric battlegroup including air (i.e. Man-Flight Simulation Facility), ships (i.e. Aegis Simulation Facility), Command and Control, Battlespace Visualization (i.e. Crew Station Technology Laboratory) and Collaboration Technology (i.e. Collaboration and Automation Research Laboratory)
  - The collaboration model will provide a significant improvement in asynchronous, distributed collaborative decision making within the Network Centric Warfare environment.

TRANSITION AND DEMONSTRATION

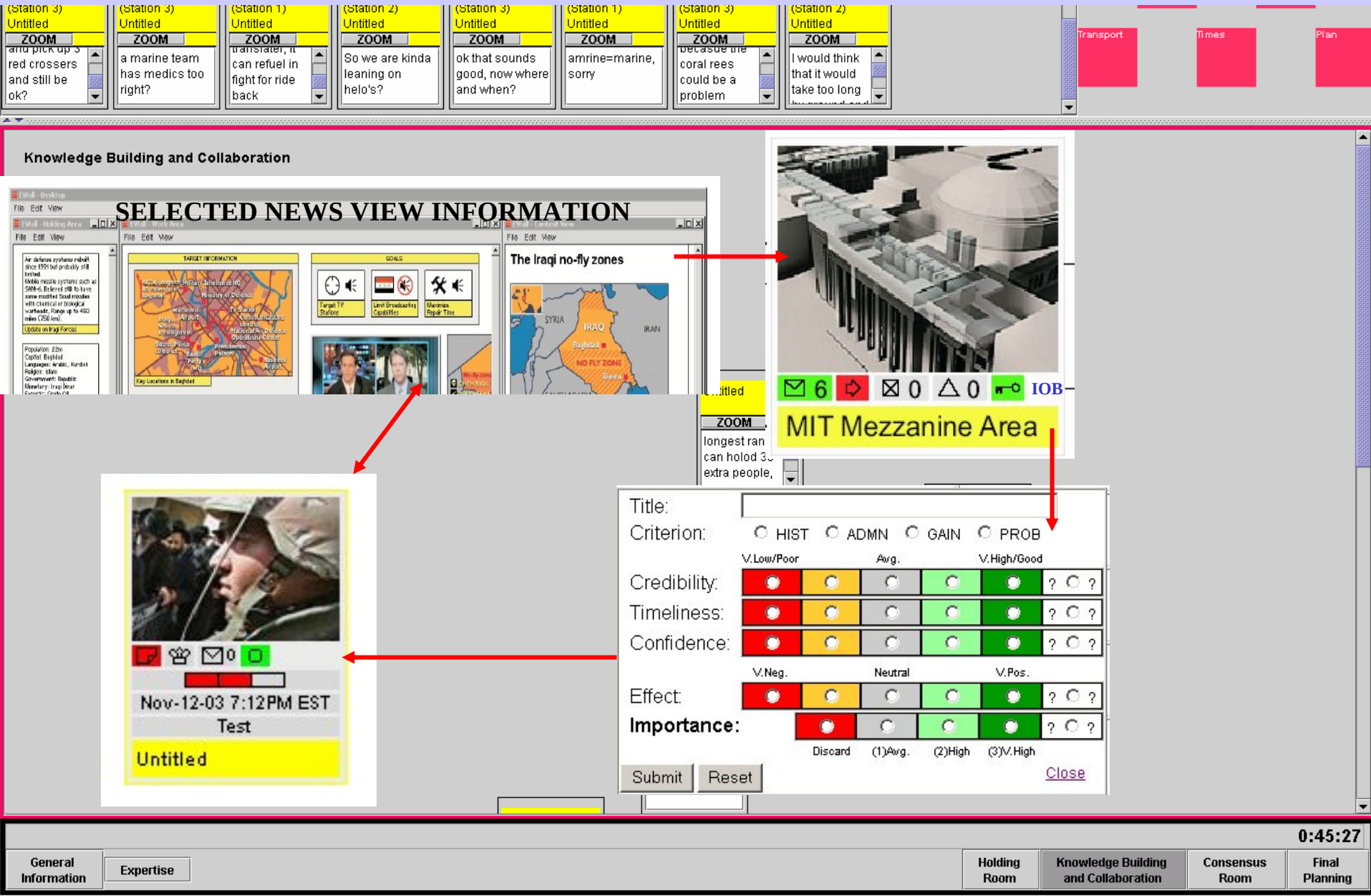
OF

STRUCTURAL MODEL OF TEAM COLLABORATION

IN

NAVAIR AND NAVAL POSTGRADUATE SCHOOL CKM TESTBEDS

Illustration of Integrated Ewall Environment for Team Collaboration (example: Ewall, Knowledge building model, Information Objects)



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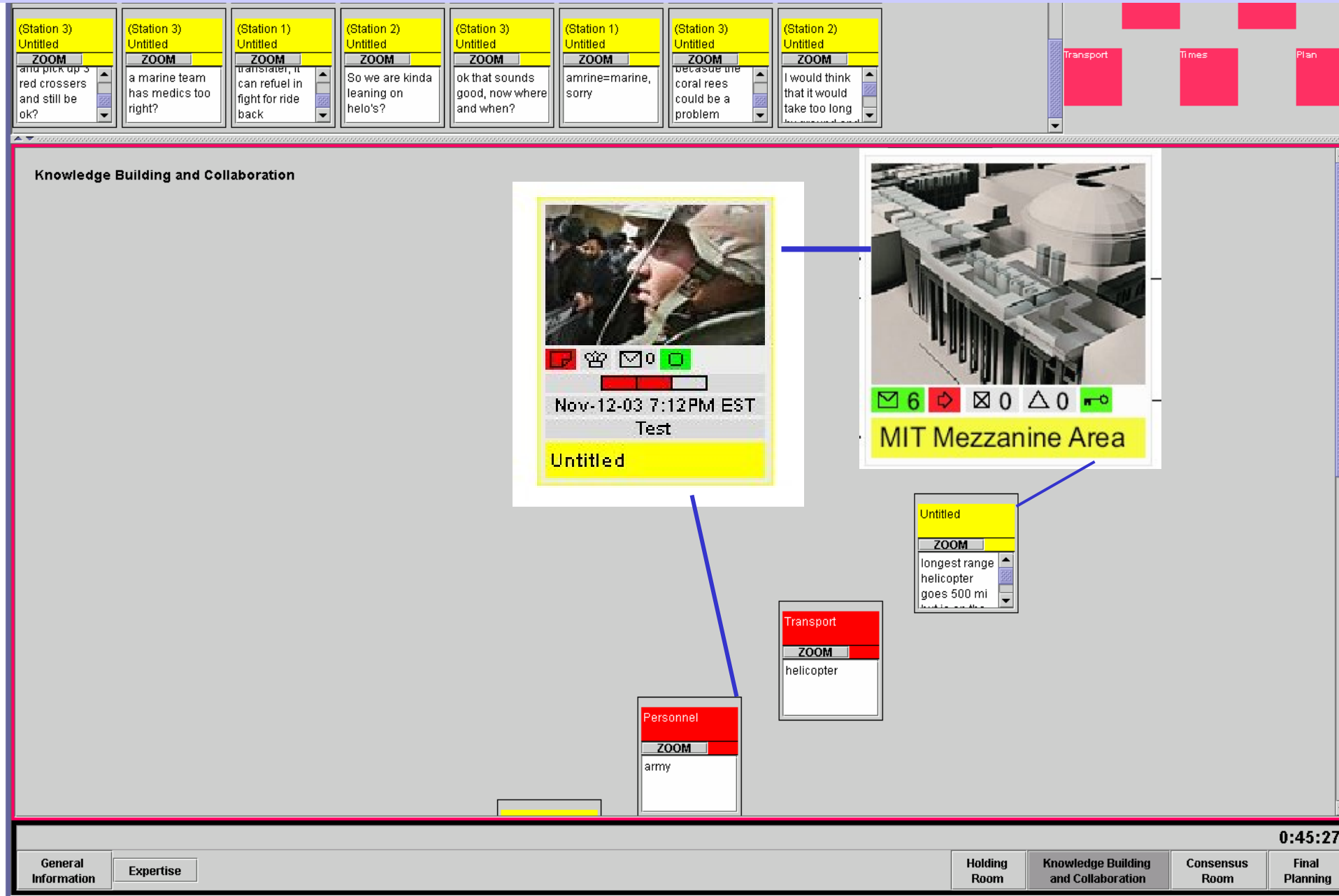

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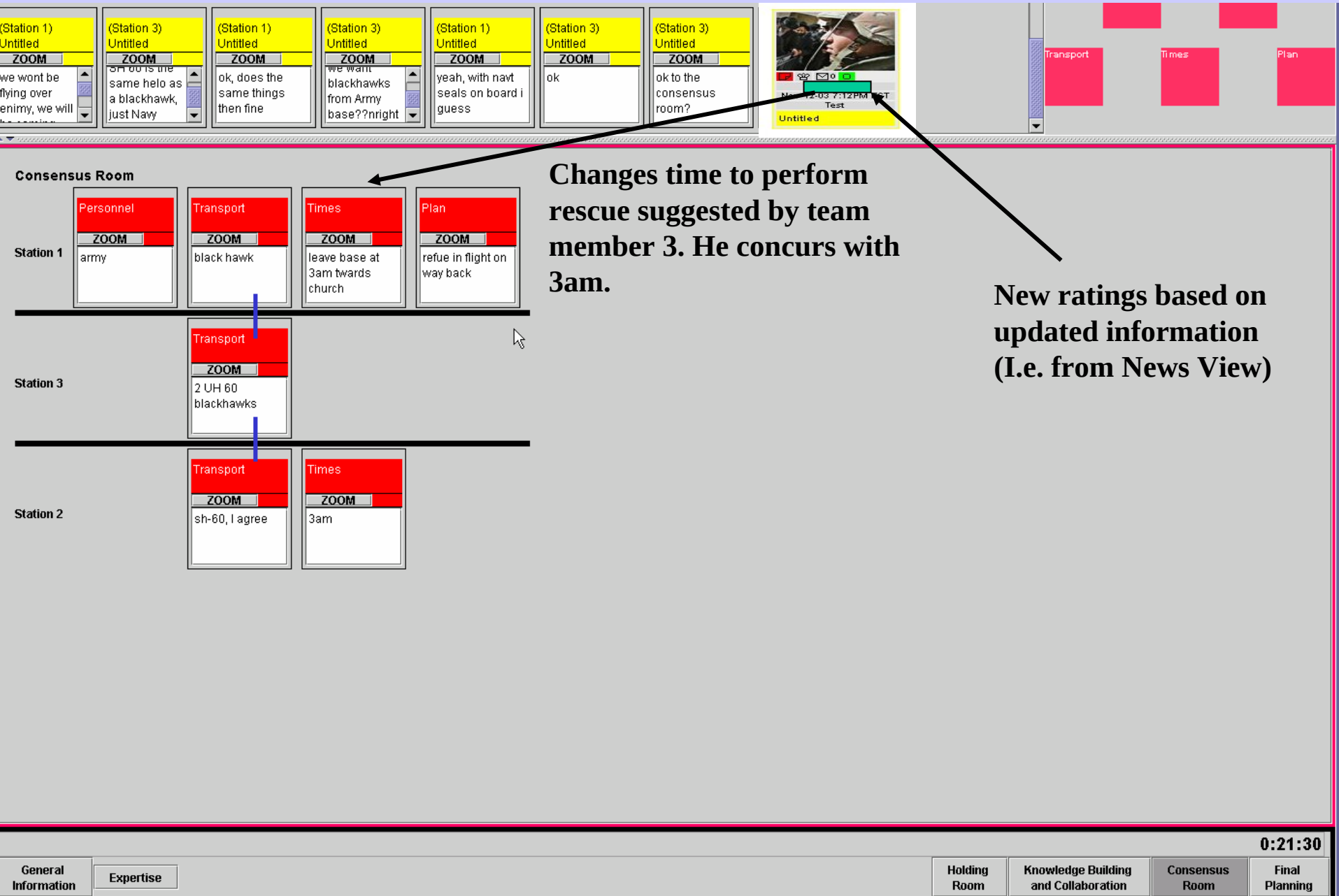

RECENT / PLANNED PUBLICATIONS

Journal Articles

•Warner, N.W., Letsky, M., Cowen, M.(In Press). Structural Model of Team Collaboration. Paper being submitted to Journal of the Human Factors and Ergonomics Society. *(peer reviewed)*

•Warner, N.W., Wroblewski, E., Vanderwalker, S., and Verma, N. (In Press). The Effect of Collaboration Mode and Knowledge Distribution on the Knowledge Building Process in an Asynchronous, Distributed Collaborative Problem Solving Task. Paper being submitted to the Journal of Human Factors and Ergonomics Society *(peer reviewed)*

• Warner, N. W. and Wroblewski, E.(2003). The Cognitive Processes Used in Team Collaboration During Asynchronous, Distributed Decision Making. Paper submitted to the 2004 Command and Control Research and Technology Symposium, June 15 –17, 2004, San Diego, CA. *(peer reviewed)*

Technical Reports

•Warner, N.W., Vanderwalker, S. and Verma, N. (2003). Collaborative Knowledge in Asynchronous Collaboration (CASC). Collaboration and Knowledge Management Workshop Proceedings, January 14-16, 2003. Office of Naval Research, Code 342, Arlington, Va.

•Warner, N.W. Vanderwalker, S., Verma, N. and Narkevicius, J. (2002). State of the Art Review of Human-Human Collaboration Research: An Integrated, Multidisciplinary Perspective. Collaboration and Knowledge Management Workshop Proceedings, January 14-16, 2003. Office of Naval Research, Code 342, Arlington, Va.

Lessons Learned

- Both face-to-face and asynchronous, distributed teams demonstrated behavior that supports the existence of Team Knowledge Construction, Collaborative Problem Solving and Team Consensus stages during collaborative problem solving. Phase I data showed that the stages are task dependent as the Outcome Evaluation & Revision stage was not used

- The significant cognitive process states were Understanding the Problem, Individual Knowledge and Team Knowledge development, Conventions for Transferring Meaning, and developing Solution Alternatives

- Knowledge Distribution (homogeneous / heterogeneous information) significantly influenced how team knowledge was developed

- Asynchronous, Distributed teams spent more time in Collaborative Problem Solving stage than face-to-face teams. Appears to be more difficult to solve collaborative problems with these types of teams even though collaboration environment is inherently more structured. Need to determine why these teams spend more time so collaborative problem solving can be facilitated

- Face-to-face teams used conventions to transfer meaning (e.g. yellow stickers, maps) whereas asynchronous, distributed teams did not use conventions. Need ways to easily create conventions with asynchronous, distributed teams (another area for agent support)